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## Long Period Variations in Terrestrial Phenomena.

By HAROLD JEFFREYS, M.A., D.Sc.

PROFESSOR H. H. TURNER has recently published two papers that cannot fail to be of value to any meteorologist interested in long period changes of climate. In the first* he submitted to harmonic analysis the 1,500-year record of the frequency of earthquakes in China and the 700-year record of the height of the Nile floods. Each analysis showed strong indications of a period of about 240 or 260 years.†

In a more recent paper‡ Professor Turner has obtained a great deal of additional and more accurate information by analysing the rates of growth of Californian Sequoias. The growth rings on the stumps of these giant trees, which have now all been felled, have been carefully measured by

* Monthly Notices of the Royal Astronomical Society, 79; 1919, p. 531.

† The length of the period could not be determined very accurately. Two periods which may both be present can be separated completely when the observations extend over an interval as long as the period of the beats between the putative variations. Thus, with observations extending over 1,500 years, it is possible to distinguish satisfactorily a period of 250 years from one of 300 years on the one hand, or 214 years on the other. Periods differing by smaller amounts, however, cannot be separated completely.

‡ Monthly Notices of the Royal Astronomical Society, 80, 1920, p. 801.

Huntington, Douglass and others. The thickness of each ring gives the growth of the tree in the corresponding year. In this way a complete record of the growth of eleven trees in each year from B.C. 274 to A.D. 1914 has been obtained and published by A. E. Douglass.* There are four trees that go still further back, but less reliance is placed on the earlier data provided by these. In each tree there is a steady decrease in the rate of growth, which is allowed for in the computation. An analysis of the growths of 2,160 years for periods equal to submultiples of the whole interval gives strong indications of periods near to 270 and 196 years, each with variations of amplitude indicating the presence of another term of nearly equal period. When the 196-year variation was examined more closely, however, it was found that another term with a period of about 100 years was even more strongly marked. This had previously been noticed by Douglass, who had, however, devoted most of his attention to periods of less than a century. The 100-year variation, like the longer ones, shows a periodic variation in amplitude and phase, attributable to an interfering term. The length of the beats indicates that the period of this is 94·4 years, and the number of observations available is such that these two periods can be determined within about two years. Professor Turner then suggests that these are really the third harmonics of two longer periods. With this hypothesis, the range of uncertainty of the longer periods is much reduced, and it is found that they are well represented by two terms of periods 303 and 284 years. The 200-year part again appears to be a compound variation, being a mixture of two whose periods are 189 and 220 years. A second harmonic of the longest period term, with a period of 151·5 years, is also detected. Most of the terms show a decline with time in their coefficients, owing to a decreased response in the tree.

The results show that the secular and long period variations in the rate of growth are represented by a formula of the type—

$$\frac{dR}{dt} = A. \exp_{10} \left[ at + \Sigma (b - ct) \cos \frac{2\pi}{T} (t - t_0) \right]$$

where A is independent of the time and depends only on the particular tree. If $t$ be measured in centuries from A.D. 0, $a = 0·0015$, and the values of the parameters for the other terms are as follows (evidently T is the period of the har-

* Climatic Cycles and Tree Growth (Carnegie Institute, 1919). (See *Meteorological Magazine*, March, 1921, p. 47.)

monic term, measured now in centuries, whilst $t_0$ gives the date of its last maximum):—

| T | $b$ | $c$ | $t_0$ |
|---|---|---|---|
| 3·03 | 0·030 | 0·0020 | 19·07 |
| 2·84 | 0·044 | 0·0020 | 18·99 |
| 2·20 | 0·029 | 0 ? | 17·69 |
| 1·89 | 0·039 | 0·0020 | 17·46 |
| 1·01 | 0·025 | 0·0020 | 19·17 |
| 0·944 | 0·015 | 0·0020 | 19·10 |

The value of $c$ for the 220-year term is uncertain. The amplitude of this variation apparently remained nearly constant, or even slightly increasing, for three-quarters of the interval discussed, but then showed signs of a decline. This term may be in a class by itself, but its anomalous behaviour may be only accidental.

The 151·5-year term has a coefficient of the order of 0·01, but its value is difficult to determine with any accuracy. The probable value of a harmonic coefficient determined from a random set of values with the same standard deviation is not explicitly stated, but appears to be about 0·007.

The relation of tree-growth to climate is sufficiently obvious, and it is likely that these periodicities represent real variations in climate, especially as indistinguishable periodicities are found in the results obtained from the Nile floods and in the Chinese records of sunspots.

What is more difficult to understand, however, is how these phenomena come to be related to the Chinese earthquakes, which are also well represented by the two longest of Professor Turner's periods. It may be noticed that there was a maximum rate of growth of the Sequoias about 1604, and of the Flagstaff trees about 1610. The nearest earthquake maximum was about 1638, and the nearest Nile flood maximum (probably) about 1660.

Still more remarkable is the fact that the period of the longest unexplained fluctuation of the moon's mean motion is also about 250 years. This has been observed for less than one period, so that modern observations alone are incapable of disentangling it from the secular acceleration, much less from a harmonic variation of nearly the same period. Dr. Fotheringham's independent determination of the secular acceleration from ancient observations, however, has rendered it possible, and has shown that the period of the fluctuation is probably of about the same length. The abnormality in longitude was apparently a maximum about 1790, almost the time of the earthquake minimum.

A very tentative explanation would be that the earth was varying in size, and that a high frequency of earthquakes

corresponded to the most rapid expansion. The maximum radius, and hence the minimum velocity of rotation, would then come a quarter of a period after the earthquake maximum, and the earth's angular displacement would therefore be behind its scheduled time by the maximum amount half a period after the earthquake maximum. But the effect of the earth being behind time is that all heavenly bodies appear to be before time, and so the moon's excess in longitude is greatest at this time—in other words, at the earthquake minimum. A plausible connection between the earthquakes and the climatic phenomena is still more difficult to suggest.

## The Artificial Control of Weather.

ON March 9th Sir Napier Shaw delivered a lecture on the artificial control of weather before the Cambridge University Aeronautical Society. A resumé of the lecture is given below.

"The control of weather has been a subject of vivid interest from the dawn of history down to the present day. It is woven into the fabric of every form of civilisation. The claims of the rain-maker are in some cases modern ; but they are not exclusively modern, and are not to be regarded as one of the many signs of the progress of physical science in civilised nations. . . . Quite deep down in human nature is apparently the feeling that if man cannot himself control the weather, at least he knows who or what can ; and he can bring influence to bear upon the spirits of the air that will guide the control in the manner desired." Few subjects of speculation are more interesting than the system of control indicated by Greek mythology. Even in the eighteenth century, when as a result of the discovery of the laws of planetary motion the conception of "laws which never shall be broken" was growing on all sides, "the weather was regarded as still at the immediate pleasure of the Almighty Law-giver in Whom had become gathered all the several powers of the Greek immortals." The transition from the mythological position to the theistic position was very gradual, and is perhaps not complete in parts of Europe even to-day.

"In the course of my experience at the Meteorological Office I have had to be responsible for considered opinions on many offers of controlling the weather in some form or other. This was specially the case during the war." Many astonishing suggestions have been made from time to time, but the objects of all of them, good or bad, are curiously limited. "I have never seen any suggestions for beginning

where nature begins and turning winter into spring or summer for a particular district by warming the open air or the open sea, or for drying the roads by operating on the humidity of the open air. The objects to which the operations are proposed to be directed are such as the avoidance of hail by the dissipation of thunder clouds. This appeals particularly to the regions which surround the Alps. The production of rain in regions where rain is specially wanted for the maintenance of crops is another object, and, thirdly, the dissipation of fog, and this last has now become transcendently important in flying. The methods proposed are either mechanical or electrical."

The production of noise has always been regarded as influential in controlling the weather, possibly on account of the constant association of rain with the noise of thunder. When firearms were invented their use replaced the ringing of church-bells formerly in vogue among the peasants. The belief in the efficacy of firearms expresses itself periodically in European vine-growing districts. "It was epidemic in a very severe form at the end of last century because somebody had devised a new gun or mortar; pointed upwards it discharged a vortex ring of smoke which could be seen to reach the clouds." The mortars were increased in size until they were 40 feet high, and much money was spent, but the result was indecisive, persons in more northerly latitudes thinking the influence disproved, and those in more southerly ones thinking it proved.

Subsequent French proposals for setting up *paragrèles* "in the form of tall structures carrying metallic points for the discharge of electricity to neutralise the electricity of the thunderclouds" were interrupted by the war.

A variation of the gunfire method is the use of a violent detonation such as is produced by dynamite explosions, heavy gunfire, and so on. "It draws its support largely from the fact that many battles have ended in, or been followed by, downpours of rain. Historically, battles are summer phenomena, and doubtless many summer days of less momentous importance have closed with downpours of rain. . . . There is no ground *a priori* for supposing that concussion would have any effect at all upon the condensation of vapour and clouds. And in any attempt to prove the influence by rainfall which occurred subsequently to the explosions we have no means of comparing actuality with what would have happened if the explosion had not occurred. . . . The effect of extensive gunfire may be regarded either as physical, arising from the detonations, or chemical . . . The direct effect of the detonation is probably nothing at all, and the chemical

effect inconsiderable compared with the daily combustion of fuel in the Manchester district."

Mr. Cole, a Canadian airman, suggests rain production by means of liquid air sprayed from an aeroplane. While a certain amount of condensation is thus assured there is a risk that the rain might evaporate before reaching the ground.

Other rain-making suggestions are even less attractive. The method of throwing dust from an aeroplane on to clouds 5,000 feet high, tried at Pretoria, was unsuccessful, as might by expected, since if cloud is already present dust is superfluous. A similar proposal, using a balloon, was made some years before the war for the dissipation of London fog.

"An electrical installation in Australia for discharging electricity from kites was said to have produced enough rain to fill a large tank in a region that was suffering from lack of rain; but the observations of the time showed that the whole country for hundreds of miles around was uniformly fortunate."

"In the present generation not only are the laws of motion of the heavenly bodies regarded as never to be broken, in spite of the fact that Einstein and others may alter the form; but there are many new laws of physics and chemistry which have an equal claim to be regarded as inexorable in the study of weather; and, moreover, the powers of the laboratory and the workshop have become so much enlarged that the new spirit of humanity is not disposed to take the vagaries of the spirits of the air lying down. If we really understand them we ought to be able to direct the operation of the forces of nature; and we find a disposition to ask whether we cannot ourselves take over the forces of the air, and if not, why not?" Many opinions of the futility of human effort have been proved to be wrong; all awkward corners may be turned by new inventions. These matters are largely questions of scale; for practical purposes impossibility is reached when the money and material required exceed the limit of what is available. "We can do anything with a quantity of air in a small enclosure in a laboratory. We can, certainly, by artificial means, make cloud or rain in the enclosure and disperse it or evaporate it at will after it has been formed. We could easily find out whether the detonation of a pistol or a small charge of dynamite at a suitable distance would produce any effect upon an artificial cloud, though I have never heard of the experiment being tried. The important question is whether we can extend such operations from the laboratory to the open air. We are here up against the important consideration that a cube of air 10 metres each way weighs more than a ton. If it is foggy it may contain 5 kilogrammes of water drops, and a

millimetre of rain over the same area weighs 100 kilogrammes. The amount of heat released by the condensation of a kilogramme of water is about 600 kilogramme-centigrade units, which are equivalent to $2 \cdot 5 \times 10^{13}$ ergs, or approximately one horse-power-hour ($2 \cdot 7 \times 10^{13}$ ergs). Hence evaporating a 10-metre cube of air containing fog is equivalent to 5 horse-power-hours, and a millimetre of rain over the 10 metre square, 100 horse-power-hours; over a square kilometre, a million horse-power-hours."

Another idea, the basic theory of which is probably at fault, apart from questions of scale, is the prevention of development of fog at sea by pouring oil on the water and so stopping evaporation in the environment of the ship.

The modern problem of clearing fog from aerodromes has been the subject of several suggestions. The chief of these are local heating by means of coal fires, mechanical driving away of foggy air by propellers capable of giving a speed of 100 kilometres per hour to the propelled stream, and electrical methods. Again it is a question of scale. Both within a laboratory and on the larger scale of furnace flues a brush discharge of electricity will clear away dust, smoke and cloud like magic. Sir Oliver Lodge's experiments in clearing Liverpool from fog were not decisive, and in any case it is not very desirable to have an installation for brush discharge, which comes pretty near to sparking, in the neighbourhood of an aerodrome.

"What it comes to, then, is that all the suggestions for the human control of weather oppress one not by any mistaken conception of physical processes, but by the 'scale effect.' Within our knowledge we are lords of every single specimen of the atmosphere which we can bottle up and imprison in our laboratories, our furnace flues and our greenhouses; but in the open air the ordinary inexorable laws which control the behaviour of the atmosphere when we are awake and when we are asleep, have such enormous masses of energy in the form of warmth and water vapour in reserve that our own little reserves are not equal to making any serious impression on the course of nature." The course of the weather may, however, be affected by the explosion of a great volcano, and it would be interesting to consider "how far our reserves of available energy compare with the destruction of Pompeii, the disappearance of the island of Krakatoa, or the eruptions of Mt. Pelée and La Souffrière."

## Meteorological Office Standard Wind Vane.

THE Meteorological Office Standard Wind Vane (Fig. 1) is the outcome of experiments undertaken by the Royal Aircraft Establishment in 1917 in order to design and con-

struct a vane suitable for use with the Dines Pressure-Tube Anemometer on Pyestock Tower.

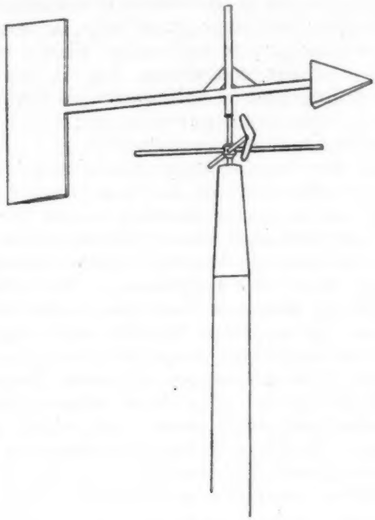

FIG. 1.

It was found that the original pattern of vane, similar to that illustrated in the Observer's Handbook with the Direction Recorder, would not respond to changes of direction of light winds. This may be understood when one considers that the usual exposure involves a length of about 40 feet of direction-transmitting tubing connecting the head to the recorder, whereas 150 feet were required at Pyestock, the vane being exposed at a height of 152 feet above the ground and the recorder situated at the base of the tower. This tubing is, of course, rigidly connected to the moving head and its weight is borne by the bearing of the head on its spindle. This abnormal weight of tubing naturally brought into play a much larger frictional force at the bearing, which the turning moment of the vane, with small angles of incidence to a light wind, was unable to overcome. The result was loss of sensitivity of the vane to changes of direction of light winds. Consequently, a new head was designed, the vane having the same area as the original, but about eight times the turning moment. This was accomplished by setting the tail so that its centre of pressure was at a maximum distance from the

axis of rotation. Also, the tail was given a "streamline" cross-section as in an aeroplane tail (*see* Fig. 2), as this gives

FIG. 2.—CROSS-SECTION OF TAIL.

a greater couple than a flat plate of similar dimensions. This property of aerofoils is most marked when the angles of incidence of winds are small.

Two heads were compared in a wind channel; either vane was set at an angle to the wind and the corresponding turning moment was determined. It was estimated that with a wind of 100 feet per second (68 m.p.h.) the turning moment of the fish-tail vane when set at 10° from the wind would be 2 foot-pounds, but the moment for the new vane in like circumstances would be 13 foot-pounds. These results are in accordance with the expectation of the designers.

From the results mentioned above it was clear that the new vane was more efficient than the original "fish-tail" pattern, and all new heads were ordered to the specification of that designed for Pyestock, excepting that the vanes were to be made of copper instead of aluminium. Experience with an aluminium head at Spurn had shown that, even when stove-enamelled initially, aluminium weathers badly. Although this alteration necessarily increased the moment of inertia of a head and possibly slightly decreased its efficiency, the effect must have been negligible judging by a recent report on the establishment of the anemometer at Gorleston. Whereas it is possible to orientate a "fish-tail" head in relation to the recording apparatus by holding it still whilst at the top of the mast, at Gorleston this was found impossible with the new pattern head even in a gentle air, and other means of orientation had to be devised. A comparative test of the two heads in action was carried out by Captain Cave in 1918 on Salisbury Plain, where two anemobiagraphs were available. It was found that the trace given by the new head

was the more sensitive with winds under 5 miles per hour, although with winds over 10 miles per hour there was no appreciable difference in the two records. It has also been noticed that the new head will adjust itself to the direction of a light wind after a calm, whilst a flag remains undisturbed. The direction of very light winds is often of importance, as in the case of the initial stages of land and sea breezes which respond to local pressure gradients not shown on the ordinary synoptic chart, and therefore the advent of this efficient vane is of considerable value.

The vane shown in Fig. 1, with the forearms indicating the cardinal points, is a vane pure and simple, and is not intended for recording. In design it is similar to the direction-recording vane, but of two-thirds the size, as, of course, it has no work to do. The head is very nicely balanced about the top of the cylindrical portion and turns on a hard steel point on the top of the central spindle.

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## The Royal Meteorological Society.

IN accordance with custom, the March meeting of the Royal Meteorological Society was devoted to a formal lecture. The meeting was held on March 16th in the rooms of the Royal Astronomical Society, with the President (Mr. R. H. Hooker) in the chair, and the lecture, which was delivered by Dr. G. C. Simpson, Director of the Meteorological Office, was on "The South west Monsoon."

It has been held that the south-west monsoon owes its origin to the great difference of temperature which exists during the summer months between the heated land surface of India and the surrounding oceans, the general idea being that the warm air over the land rises, and damp air from the sea flows into India to take its place, thus giving rise to the strong south-west winds, the rainfall itself being due to the cooling of the air as it rises over India. This theory has to face the difficulties that the temperature over India is much higher in May before the monsoon sets in than it is during the monsoon itself; that the temperature is higher in years of bad monsoon than in years of good monsoon; and also that the part of India which has the highest temperature and the lowest pressure and where ascending currents should be the greatest, is a region of practically no rainfall throughout the monsoon.

The true explanation of the south-west monsoon can only be obtained by taking a wide view of the weather conditions over large parts of the Earth's surface during the summer of the northern hemisphere. It is then seen that the south-west winds are not due to the temperature in India, but are a relatively small part of a general circulation of the atmosphere caused by a region of high pressure over the South Indian

Ocean and a region of low pressure which extends over the whole of Central Asia. From the region of high pressure air passes northwards in the south-east trades as far as the equator, where it gets caught in the circulation around the low pressure over Asia. On account of the particular arrangement of sea and land, and of the deflection of wind-currents due to the Earth's rotation, this air travels for 4,000 miles over the sea before it reaches India, where it arrives very warm and exceedingly humid. The air would probably sweep right across India to its goal in Central Asia without producing much rainfall if it were not for the unique distribution of mountains around India. From the north of the Mekran coast, following the line of Afghanistan, the Himalayas and the mountains of Burma, there extends an unbroken wall of mountains, nowhere lower than 5,000 feet, directly athwart the air currents already discussed. These mountains catch the air, which is being driven by a pressure distribution extending from the southern Indian Ocean to the centre of Asia, in a kind of trap, out of which there is no escape except by ascension. The humid air, which begins to form rain as soon as it rises even 500 feet, is actually forced to rise between 10,000 and 20,000 feet. In consequence, large amounts of water are precipitated over the greater part of the Indian area.

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## Discussions at the Meteorological Office.

ON March 7th, Mr. Whipple opened a discussion on Meteorological Optics with special reference to the articles by Professor Humphreys in the *Journal of the Franklin Institute.** These articles have been incorporated in Humphreys' book on the Physics of the Air† which has been published recently. The absence of such a connected account of the subject of meteorological optics in the English language has been a reproach to physicists on both sides of the Atlantic, and Professor Humphreys has done well to fill the gap. Mr. Whipple mentioned, however, a few sections which he considered open to criticism, notably the theories of some of the rarer halo phenomena and of the "glory."

In the discussion, several interesting personal experiences were mentioned. Captain Douglas stated that it was usual when flying through cloud to see a corona before emergence and a "glory" on looking back at the cloud after emergence. Dr. Ghosh, of Calcutta, had seen rainbows formed by the drops of water condensed from fog on the surface of a pond; and Dr. Simpson mentioned some of the more striking forms

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* Journal of the Franklin Institute, Vol. 188, pp. 433–488 and 607–674.

† Physics of the Air, by W. J. Humphreys. Philadelphia: Lippincott, 1920. Part III.

of mirage seen in the Antarctic, and also discussed the theory of condensation nuclei.

The discussion on March 21st was opened by Lieut.-Colonel Gold, who gave an account of R. Emden's paper on "Radiative Equilibrium and Atmospheric Radiation."

In the paper the atmosphere is regarded as a series of horizontal layers bounded by planes, and each layer contains the same mass. The total radiation passing through unit area from one of the layers is $2\pi$ times the radiation emitted normally (for a black body the total radiation from unit area is only $\pi$ times the normal radiation). The absorption of radiation by any layer depends not only on the total quantity of the incident radiation, but also on the proportion of the total which comes from different directions; and the total absorption is not usually $2\pi$ times the absorption of the radiation incident normally.

The radiation for the atmosphere is different for different spectral regions, and although these are known with some precision in their general features, the finer details are not known. Accordingly, alternative approximations are made as follows:—

(*a*) Radiation is regarded as gray, *i.e.*, having a constant ratio for any wave length to the radiation of that wave length from a black body having the same temperature. With this assumption, Emden deduces that radiation equilibrium will be stable, and if conditions are steady, will give an isothermal atmosphere.

(*b*) Radiation is divided into two parts:—

(1) Solar, of which 10 per cent. is absorbed by the earth's atmosphere in vertical transmission.

(2) Earth or atmospheric radiation, of which 90 per cent. is absorbed in vertical transmission.

With this assumption, radiation equilibrium would lead to a temperature distribution in which the lapse rate in the lower 3 kilometres is much greater than the adiabatic lapse rate. The lower layers would therefore be unstable.

If the assumptions of (*b*) are applicable to the actual atmosphere, there ought to be a steady fall of temperature at 2 to 3 kilometres, due to radiation, and a steady rise of temperature at the earth's surface. This latter would be accentuated by the transfer of heat from the earth's surface to the atmosphere, which Emden neglects.

In the absence of solar radiation, Emden finds rates of cooling by radiation comparable with those found by Colonel Gold in 1909, namely, about 1° C. in the course of the night.

# Correspondence.

To the *Editors*, "*Meteorological Magazine.*"

## Simultaneous Lunar Halo and Corona.

I OBSERVED a brilliant phenomenon of this nature at 9.40 p.m., March 20th, 1921. There was a complete coloured lunar halo, an annulus and a coloured triple corona. The annulus was about 1° in diameter, and the three red rings of the corona about 3°, 5° and 8°. The 5° ring was brilliant. The cloud sheet was so smooth that its movement could not be discerned. Occasionally, however, flecks of alto-stratus passed, moving from the WNW. The surface wind was strong SW., and the air temperature 72° F. It seems probable that the halo and the annulus were formed by the cirro-stratus, the lower portion of which was falling into air above freezing in temperature, and that the triple corona was produced by a thin alto-stratus, which may have been within the lower portion of the cirro-stratus. On the previous evening, under similar weather conditions, there was a lunar halo, an annulus, and a bright corona (red 4° diameter, approximately), associated with cirro-stratus, and a much larger corona when passing thin alto-cumulus clouds, but all were not visible, complete, at once.

CHARLES F. BROOKS.

*Weather Bureau, Washington, D.C., March 25th, 1921.*

## Lunar Halo and Mock Moons.

ON the evening of March 23rd the occurrence of two mock moons was witnessed here independently by two observers besides myself.

At 19 h. 25 m. G.M.T. the half of the lunar halo higher in the sky than the moon was visible, but the colours in the halo were only faintly seen on the side to the north of the moon.

Mock moons were distinctly visible on the ring forming the halo, and at the same distance above the horizon as the moon itself. During the succeeding ten minutes they became steadily brighter, but as the circumference of the circle of light was not clearly marked the diameter of the mock moons can only be given as approximately three times that of the moon.

In addition to the mock moons there was a band of light stretching for about 8° from the southerly mock moon, parallel to the horizon, the width of it being slightly less than that of the halo.

During the occurrence of the phenomenon the sky was covered to about $\frac{8}{10}$ with cirrus clouds, and the phenomenon disappeared by 20 h. G.M.T., when these clouds moved away.

R. S. READ.

*Meteorological Office, Lympne Aerodrome, March 29th, 1921.*

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## Irregular Solar Halo and Mock Suns.

ON Tuesday, April 5th, 1921, an irregular solar halo with two mock suns was observed from Kew Observatory. The phenomenon was first noticed at about 9 h. 40 m. G.M.T., and continued up to about 10 h. 30 m. G.M.T., when it was covered by cumulus clouds.

The sun was covered at first by a sheet of cirro-stratus cloud, while towards the north and west were long bands of cirrus clouds running approximately from north to south. Small fracto-cumulus clouds then began to appear, and later increased in size and number until they obscured the phenomenon.

The radius of the halo was about 33° measured from the sun to the outer edge. On the east of the sun, a length of about 20° of the mock sun ring was seen, while on the west the length of this ring was 10°. The eastern mock sun was the more brilliant and had a reddish tint.

R. E. WATSON.

*Kew Observatory, Richmond, April 6th, 1921.*

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## Meteorological Observations during the Eclipse of April 8th.

THE observations taken at Greenwich were on the plan adopted on April 17th, 1912, when a midday eclipse of rather greater magnitude took place. The dry and wet bulb thermometers were read at 5 minute intervals and the solar radiation thermometer at $2\frac{1}{2}$ minute intervals.

At first contact, 7 h. 35 m. G.M.T., the shade temperature was 43·2°, which increased to 45·6° by 8 h. 20 m., decreased to 44·2° by 8 h. 50 m., and increased to 49·8° by 10 h. 5 m, the time of last contact. The relative humidity decreased from 81 per cent. at 7 h. 35 m. to 72 per cent. at 8 h. 25 m., increased to 74 per cent. by 9 h. 0 m., and decreased to 58 per cent. by 10 h. 5 m.

The solar radiation reading was 67·0° at 7 h. 35 m., increased to 70·5° by 7 h. 50 m., when a few small clouds began to pass, making the readings irregular till 8 h. 20 m., when the sky became cloudless again. At 8 h. 52 m. 30 s. the lowest reading, 47·5°, was obtained, five minutes after the greatest phase of the eclipse, the subsequent readings

showing a regular increase to 101·5° just after the last contact. Apparently, therefore, the drop due to the eclipse was about 38° F.

It is interesting to record that the register of atmospheric electricity, which had risen by the time of commencement of the eclipse to 300 volts per metre (approximately), fell steadily to 125 volts by 9 h., after which it rose again, becoming apparently normal before the end of the eclipse.

WALTER W. BRYANT.

*Royal Observatory, Greenwich, London, S.E.10, April 9th, 1921.*

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The following readings taken here to-day may be of interest:—

| H. | M. | Dry Bulb. °F. | Wet Bulb. °F. | Grass in full Sun. °F. |
|---|---|---|---|---|
| 8 | 10 | 44·7 | 40·0 | 49·8 |
| 8 | 24 | 44·9 | 40·1 | 47·6 |
| 8 | 35 | 44·3 | 39·7 | 36·6 |
| Darkest period— | | | | |
| 8 | 59 | 42·3 | 38·8 | 36·6 |
| 9 | 35 | 44·4 | 40·6 | — |
| 10 | 6 | 47·3 | 41·7 | — |

It was never nearly dark enough to show even the brightest stars.

H. NOWELL FFARINGTON.

*Worden, Leyland, Lancs, April 8th, 1921.*

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ABOUT the temperature changes during the solar eclipe there is little to be said, except that there was little lag after the maximum phase, when the temperature rose rapidly.

The indirect changes were of greater interest, particularly those connected with turbulence. The anemogram shows a decrease in gustiness, and before the maximum phase the gusts seemed less frequent, but afterwards were more frequent than before the eclipse. The wind showed a marked tendency to back. These changes all accompany a decrease in the coefficient of upward diffusion of turbulence due to a fall of temperature, and are regular diurnal variables.

The most striking event was the formation of cloud. It formed in precisely the same way as anticyclonic stratus forms during the night, but it never grew very thick, remaining transparent. It probably lay in the damp layer at the top of the turbulent region.

Mr. W. H. Dines has suggested loss of heat by radiation as a possible cause of similar cloud formation, but Sir Napier Shaw has pointed out that dynamical warming will probably result through air cooled in this manner being forced to descend, and this should result in an ultimate increase of

temperature. That cloud can be formed by direct cooling was clearly demonstrated. After all, if air beneath the damp layer is also losing heat, the descent of the damp layer need not be great. In this case perhaps the cloud formed before the dynamical warming had time to operate and disappeared as soon as it did, since the cloud formed slightly before, and disappeared practically at, the maximum phase instead of remaining after owing to lag of temperature.

R. FRANCIS GRANGER.

*Lenton Fields, Nottingham, April 12th, 1921.*

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## Units for Meteorological Work.

As a subscriber to your Magazine for over 30 years allow me to protest against the use of millibars and millimetres instead of the good old English inches and tenths.

The former entail constant calculations, and I fail to see the utility of them.

Speaking to a F.R.Met.Soc. a short time ago about them, he simply replied " I hate them." ROBERT CROSS.

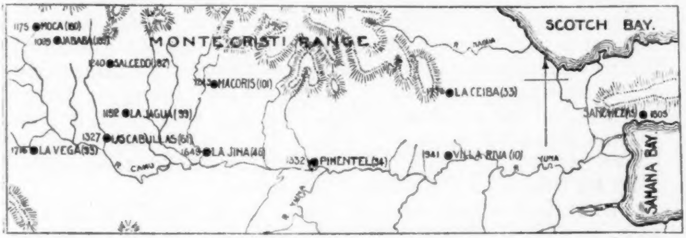
*Worstead, Norwich, March 28th, 1921.*

[The case for the newer units has been set out many times, and not many people would deny that they have advantages, though these advantages are perhaps more apparent to the physicist who has to handle meteorological data than to the observer. The question appears to be whether the advantages outweigh the serious objections that, being familiar with the old units, we find it difficult to think in terms of new ones, and that so many observers of long standing are equipped with instruments graduated by the old system. A new generation of meteorologists has, however, grown up in the last ten years, and to these the millibar and millimetre are more familiar than the inch. When one knows that 1,014 millibars is the average pressure for London at sea-level, one does not trouble oneself about the number of inches of mercury it represents, though there is undoubtedly a strong temptation to convert the current reading from one scale to another instead of familiarizing oneself with new terms. The editors of a magazine like this, which circulates among readers of all shades of opinion, require advice in deciding how far they should give statistics in duplicate in two units, and how far they should expect their readers to accustom themselves to reading figures in the newer units. It must be admitted that doubling the entries is a clumsy device at the best, but all the same it may be desirable to adopt it for a while, and we shall hope to get the views o readers on the point.—ED. M.M.]

# NOTES AND QUERIES.

## The Rainfall of San Domingo.

Meteorological data from the Dominican Republic, which occupies the eastern half of the island of San Domingo, are extremely rare, and records which have been received at the Meteorological Office from Mr. W. A. Elders, the General Manager of the Samana and Santiago Railway, and which refer to 12 rain gauges installed by him during and since 1913, are especially welcome. The railway occupies the trough-like valley of the Yuna river and its tributaries, and extends westwards from Samana Bay, in the north-east of the island. The distribution of the stations is shown on the accompanying map, the distance between La Vega and




Rainfall in San Domingo in mm. (heights in metres).

Sanchez being very nearly 60 miles. The figures in brackets to the right of the name show the height in metres, and the figures without brackets indicate the mean annual fall in millimetres for the seven years 1913, 1914, and 1916 to 1920. The incomplete series have been extended to the full period by comparison with La Vega and Sanchez.

In the West Indies the prevailing trade wind blows from east-north-east, and this wind readily penetrates into the Yuna Valley through Samana Bay and Scotch Bay, giving annual falls exceeding 1,600 mm. at most stations near the main stream and its continuation the Camu river. The north-western district, however, between Las Cabullas, Macoris and Moca, lies to the south-west of the Monte Cristi Range, which here rises sharply to an elevation of over a thousand metres. This range probably has a heavy precipitation on its northern side, but by the time the trade wind has passed its crest it has lost much of its moisture ; hence the rainfall in its "shadow" is appreciably less than in the more open valley, averaging only 1,200 mm. At Port au Prince, on the west coast, which is similarly sheltered,

the annual mean from 1888 to 1912 is 1,379 mm. The small total at Pimentel, 1,332 mm., is probably due to the local conditions of exposure.

The series of seven years is only sufficient to show the general trend of the annual variation, but the following table for Sanchez and La Vega is of interest. Data for Port au Prince have been added for comparison :—

| — | Jan. | Feb. | Mar. | Apr. | May | June. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| Sanchez - - | 97 | 82 | 104 | 129 | 163 | 199 | 212 | 224 | 149 | 132 | 211 | 104 |
| La Vega - - | 117 | 92 | 86 | 143 | 193 | 174 | 183 | 103 | 123 | 174 | 256 | 72 |
| Port au Prince - | 31 | 57 | 95 | 165 | 244 | 88 | 62 | 135 | 201 | 182 | 78 | 41 |

Apart from November, whose prominence would probably be less marked if a longer series of years were available, the rainiest months are May to September at Sanchez and April to July at La Vega. In summer the frequency of north-easterly winds decreases and that of easterly winds increases, hence Sanchez, on the southern slopes of a range of hills, has an increased rainfall in these months. La Vega, in the interior, shows indications of two wet periods, in which it resembles Port au Prince, in the west of the island.

The variation from year to year is fairly considerable, and is quite different at Sanchez and La Vega. The range in the interior is much greater than on the coast, though the average is not greatly different.

| — | 1913. | 1914. | 1916. | 1917. | 1918. | 1919. | 1920. | Average. |
|---|---|---|---|---|---|---|---|---|
| | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| Sanchez - | 2,070 | 2,007 | 1,628 | 1,866 | 1 422 | 1,777 | 1,864 | 1,805 |
| La Vega - | 1,581 | 1,399 | 2,242 | 2,561 | 1,793 | 1,390 | 1,048 | 1,716 |

The railway passes through a rich agricultural district, and the study of the rainfall is therefore likely to be of considerable economic importance. C. E. P. BROOKS.

## Extension of the Meteorological Equipment at Rothamsted.

THE Rothamsted Experimental Station recently set up a Statistical Department under the charge of Mr. R. A. Fisher, M.A., Fellow of Caius College, Cambridge, assisted by Miss W. A. Mackenzie, B.Sc., late of the London School of Economics, and a thorough statistical examination of the

Rothamsted data has been begun. The field records date back to 1843 and are unusually complete from 1852 onwards; the ordinary meteorological records also go back for many years.

The data are unusually homogeneous, and satisfactory from the statistical point of view. Nowhere in the world is there such a mass of material capable of throwing light on the relationships between weather and crops.

From a preliminary survey of the data it has become evident that refinements in the measurements will be needed both in dealing with the soil and with the weather. It is essential that statistical deductions should be tested by direct experiments, and for these the ordinary observational methods are not sufficient.

The Soil Physics Laboratory is equipped for carrying the necessary refinements into the measurements of soil-factors, but the Meteorological section is not. After consultation with the Meteorological Office and the instrument makers, it is proposed to set up a Negretti and Zambra Natural Syphon Rain Gauge to give a continuous record of rainfall, a Transmitting Thermometer, large size, for continuous records of soil temperatures, an Anemobiograph, and a Cup Integrator (with N.P.L. certificate) for continuous wind records.

Unfortunately the Treasury Minute with regard to new expenditure prevents the station from approaching the Ministry of Agriculture for the necessary funds, and the Committee is, therefore, left to raise the money itself. The total sum required is 160*l.*

Colonel Mellish, of Hodsock Priory, has opened the list with a donation of 10*l.*, and it is hoped to complete the list at an early date so that the improved measurements may begin at once. The secretary of the Rothamsted Experimental Station, Harpenden, will be happy to give information to any who would feel disposed to help the scheme.

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## Terminal Hours for Maximum and Minimum Temperature.

It has been generally regarded as the correct practice to take extreme temperatures for periods of 24 hours, maximum and minimum thermometers being set at a certain hour on one day and read at the same hour the next day. At the telegraphic stations the thermometers have been set at 7 h.,

an hour which nearly coincides with the minimum of the diurnal variation of temperature, and as a result there is frequently uncertainty as to whether a minimum temperature actually occurred near the time at which the thermometer was set or near the time at which it was read. The same difficulty occurs, though not with equal frequency, in the observations at auxiliary climatological stations where the readings are at 9 h. and at the normal climatological stations where (in accordance with international convention) they are at 21 h. Indeed, no arrangement of the sort can give satisfactorily the highest and lowest points of the curve of temperature variation in all circumstances.

For some years past the rule with regard to grass minimum thermometers has been to set in the late afternoon or evening and to read in the morning, thereby avoiding the anomaly of counting two ground frosts for one cold morning. A similar rule is now being adopted for the extreme thermometers in the screen, at any rate, at the stations of two important classes.

From March 1st, 1921, the extreme temperatures used for the telegraphic stations have been the maximum for the day, *i.e.*, from 7 h. to 18 h., and the minimum for the night, *i.e.*, from 18 h. to 7 h. The thermometers in question are set twice a day, so that the night-maxima and day-minima will be available for reference, but they will not be utilised in the ordinary statistical summaries.

At the health resorts contributing daily reports for circulating to the newspapers a like change was made on April 3rd, the first day of Summer Time. The day-maxima and night-minima for these stations refer to the periods 9 h. to 17 h. and 17 h. to 9 h., respectively. Maxima for 9 h. to 9 h. and minima for 17 h. to 17 h. are to be placed on record, but statistics will be based on the day-maxima and night-minima.

The previous practice at the health resorts involved the use of different extreme temperatures for the telegraphic reports and for the statistical summaries, a course which has frequently led to confusion.

The drawback to improvements in the routine of meteorological observations is the break of continuity in the record. The effect of the changes which have been mentioned must be to lower the average of the maximum temperatures and to raise the average of the minima. The displacements of the averages are very small in summer, but in winter they may reach half a degree Fahrenheit. It is hoped that precise statistics by which normal values may be corrected will soon be available for publication.

# Official Publications.

## Report of Proceedings of the Third Meeting of the Commission for Weather Telegraphy, London, 1920.

An account of the proceedings of this commission was published in the December number of the *Meteorological Magazine.* The report, which is now issued, contains, in addition to the minutes of the meetings and full accounts of the various specifications adopted, a useful summary of the revised codes. The memoranda which formed the basis of the discussions at the meeting are set out in a series of appendices.

# News in Brief.

News is received from the Naval Attaché, Buenos Aires, that the Argentine sloop "Uruguay," under the command of Lieutenant Domingo Casamajor, sailed on February 16th, 1921, with the reliefs for the staff of the Argentine Meteorological Observatory on Laurie Island, South Orkneys. She may call at South Georgia on the return voyage.

On April 7th and 14th, at 3 p.m., Mr. C. T. R. Wilson, F.R.S., delivered two lectures on "Thunderstorms" (the Tyndall Lectures) before the Royal Institution.

# The Weather of March.

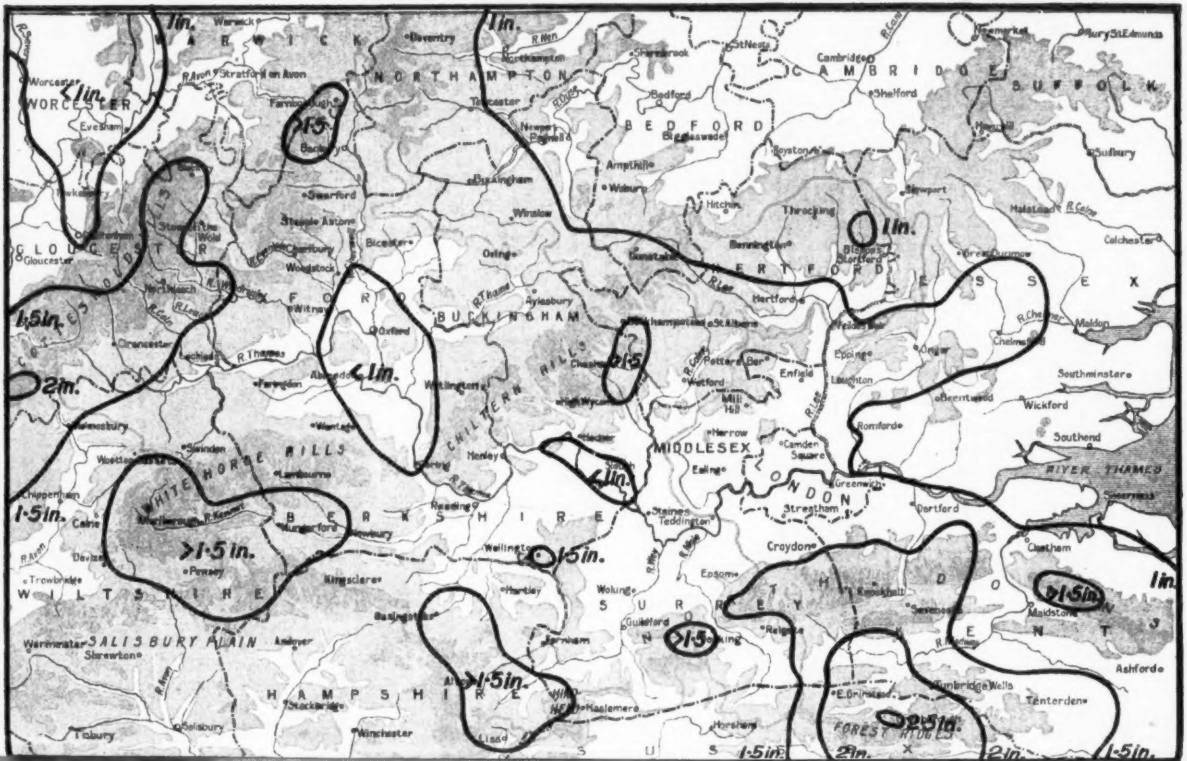
The conditions over north-west Europe during March were of a westerly to south-westerly type, with frequent depressions in the neighbourhood of the Arctic circle, and relatively high pressure between the Azores and Central Europe. In the west and north of the British Isles the weather was stormy and unsettled, with a good deal of rain. In the south and east, and the adjacent regions on the Continent, the weather was mostly fair and dry. As in the two preceding months, there was a marked absence of severe wintry weather over western Europe generally, and even in Sweden there was little frost after the 9th. Brief incursions of polar air were accompanied by snow in the northern districts of the British Isles at times in the first week, and in the western districts on the night of the 28th, but milder weather followed at once in every case.

Except locally in the early hours of the 25th, fog was almost entirely absent during the month. Low clouds were prevalent in the western but not in the eastern districts. In south-east England there was one day with persistent very low cloud.

The month opened with deep depressions moving eastward near the Arctic circle, bringing heavy rain to west Scotland, 22 mm. being measured at Eskdalemuir on the 3rd. Temperature was variable, and there was snow in parts of Scotland on the 2nd, and a heavier fall on the 5th, on the north side of a small depression which formed off north-west Ireland and moved eastward. Near sea-level in the south of Scotland there was rain or sleet on this occasion, amounting to 20 mm. at Renfrew and 19 mm. at Leith. An associated "V"-shaped secondary crossed England on the following day and caused rain or sleet generally. In south-east England a fine warm day was followed by a very cold wet evening, the wind veering suddenly from west to north. The cold snap was very brief, as pressure fell rapidly in Ireland and a warm westerly type was again established by the 8th, which proved the beginning of a long spell of mild weather, with a series of deep depressions moving north-east across Ireland, and an anticyclone over Central Europe. In the south-east half of England the weather was fair, but the western and northern districts were affected by a series of small secondaries which moved quickly north-eastward, causing gales and heavy rain in places, and occasional local thunder and hail. Among the more notable rainfall measurements during this period were 21 mm. at Blacksod Point on the 10th (partly in the form of sleet), 25 mm. at Valencia Observatory on the 12th, 27 mm. at Eskdalemuir on the 13th, and another 27 mm. at the same station on the 15th. The pressure distribution became more westerly by the 18th, and small secondaries moving eastward caused moderate falls of rain in all districts, including south-east England. On the afternoon of the 20th there were thunderstorms at Felixstowe and Yarmouth, in a cold north-west current. Next day fair mild weather set in again except in the western districts, Aberdeen having a maximum of 60° F. By the 23rd there was again a very deep depression over Ireland, and an anticyclone over Central Europe, with rain in the west and north-west, but fair weather in the south-east. The anticyclone moved westward, and the weather was brilliantly fine in southern England on the 24th and 25th. At South Farnborough temperature reached 65° F. on the 24th and 64° F. on the 25th, but fell to 25° F. in the screen on the night of the 24th.

The anticyclone continued to move westward, and the weather became cloudy and showery and colder generally on the 26th. On the 28th a deep depression from the Atlantic reached the north of Scotland and caused a gale in many

# THAMES VALLEY RAINFALL —— MARCH, 1921.




ALTITUDE SCALE

| Below 250 feet | 250 to 500 feet | 500 to 1000 feet | Above 1000 feet |
|---|---|---|---|

SCALE OF MILES

0 5 10 15 20

H.M. Stationery Office Press, Kingsway, W.C.2.

Ps. 3330/341. Wt.88. P.16. 1050 4/

places in England and Ireland, and rain generally, as much as 33 mm. at Eskdalemuir. In the evening the depression suddenly became stationary and began to fill up, but a "V"-shaped secondary caused snow in Ireland, Wales and parts of the west of England during the night, and showers of hail and rain and local thunder in other parts of England during the 29th. There was local frost on the night of the 29th, the minimum at Howden being 24° F. Mild weather soon set in again as the depression and its secondary filled up rapidly and pressure fell decidedly in Ireland. On the last day of the month an anticyclone approaching from south-west caused fair mild weather to set in over England and east Scotland, temperature reaching 63° F. at Ross-on-Wye and 62° F. at Aberdeen. C. K. M. D.

## Rainfall in the British Isles, March 1921.

THE rainfall was again markedly below the average in England except in the extreme west, being less than half the average in the east Midlands. An excess of more than 50 per cent. occurred over the whole of the western half of Scotland and locally in Ireland, and more than twice the average fell in the West Highlands. In the latter district the area with more than 250 mm. (10 inches) was exceptionally large for the season, extending from Bute to Cape Wrath. More than 500 mm. (20 inches) fell in the west of Inverness-shire and in the centre of the English Lake District. As much as 250 mm. (10 inches) fell only locally in the Welsh uplands. In the dry district of the east less than 25 mm. (1 inch) fell practically everywhere between the Thames estuary and Northumberland, the 25 mm. line through the Midlands being as far to the west as Leicester. Only relatively small areas in the east of Scotland and Ireland had less than 75 mm. (3 inches).

The general rainfall expressed as a percentage of the average was:—England and Wales, 101; Scotland, 170; Ireland, 129; British Isles, 133.

In London (Camden Square) the mean temperature was 46·8° F., or 4·6° F. above the average. The duration of rainfall was 28·1 hours, and the evaporation ·96 in.

## Weather Abroad: March, 1921.

NUMEROUS depressions affected the Scandinavian area, causing frequent gales and rain, but no very large individual rainfall records were made at any of the stations from which reports are received. There were occasional reports of snow, but on the whole the month was unusually mild. Further south the weather was mainly fair, but the secondaries which

(*Continued on* p. 84.)

## Rainfall Table for March 1921.

| STATION. | COUNTY. | Aver. 1881—1915. | 1921. | | Per cent. of Av. | Max. in 24 hrs. | | No. of Rain Days |
|---|---|---|---|---|---|---|---|---|
| | | in. | in. | mm. | | in. | Date. | |
| Camden Square | *London* | 1·83 | 1·19 | 30 | 65 | ·30 | 6 | 13 |
| Tenterden (View Tower) | *Kent* | 2·14 | 1·57 | 40 | 73 | ·44 | 29 | 17 |
| Arundel (Patching Farm) | *Sussex* | 2·15 | 1·27 | 32 | 59 | ·42 | 17 | 9 |
| Fordingbridge (Oaklands) | *Hampshire* | 2·33 | 1·53 | 39 | 66 | ·27 | 28 | 21 |
| Oxford (Magdalen College) | *Oxfordshire* | 1·53 | ·85 | 22 | 56 | ·13 | 28 | 15 |
| Wellingborough (Swanspool) | *Northampton* | 1·79 | ·77 | 20 | 43 | ·16 | 19 | 16 |
| Hawkedon Rectory | *Suffolk* | 1·90 | ·87 | 22 | 46 | ·20 | 19 | 13 |
| Norwich (Eaton) | *Norfolk* | 1·91 | 1·19 | 30 | 62 | ·22 | 19 | 13 |
| Launceston (Polapit Tamar) | *Devon* | 2·98 | 3·40 | 86 | 114 | ·58 | 13 | 23 |
| Sidmouth (Sidmount) | „ | 2·54 | 1·65 | 42 | 65 | ·26 | 14 | 19 |
| Ross (Chasedale Observatory) | *Herefordshire* | 2·03 | 1·33 | 34 | 66 | ·27 | 13 | 18 |
| Church Stretton (Wolstaston) | *Shropshire* | 2·36 | 2·62 | 66 | 111 | ·52 | 14 | 22 |
| Boston (Black Sluice) | *Lincoln* | 1·56 | ·82 | 21 | 53 | ·16 | 19 | 15 |
| Worksop (Hodsock Priory) | *Nottingham* | 1·69 | ·85 | 22 | 50 | ·17 | 27 | 17 |
| Mickleover Manor | *Derbyshire* | 1·78 | 1·27 | 32 | 71 | ·18 | 3 | 20 |
| Southport (Hesketh Park) | *Lancashire* | 2·23 | 2·80 | 71 | 126 | ·35 | 13 | 24 |
| Harrogate (Harlow Moor Ob.) | *York, W. R.* | 2·26 | 1·95 | 50 | 86 | ·26 | 3 | 19 |
| Hull (Pearson Park) | „ *E. R.* | 1·82 | 1·02 | 26 | 56 | ·18 | 25 | 16 |
| Newcastle (Town Moor) | *North'land* | 2·11 | 1·08 | 27 | 51 | ·18 | 25 | 14 |
| Borrowdale (Seathwaite) | *Cumberland* | 11·15 | 20·05 | 509 | 180 | .. | .. | .. |
| Cardiff (Ely Pumping Stn.) | *Glamorgan* | 3·21 | 3·21 | 82 | 100 | ·53 | 3 | 26 |
| Haverfordwest (Gram. Sch.) | *Pembroke* | 3·41 | 5·10 | 130 | 150 | ·77 | 15 | 26 |
| Aberystwyth (Gogerddan) | *Cardigan* | 3·47 | 4·42 | 112 | 127 | 1·18 | 2 | 17 |
| Llandudno | *Carnarvon* | 2·17 | 1·97 | 50 | 91 | ·30 | 28 | 19 |
| Dumfries (Cargen) | *Kirkcudbrt.* | 3·61 | 6·82 | 173 | 189 | 1·35 | 15 | 29 |
| Marchmont House | *Berwick* | 2·65 | 2·35 | 60 | 89 | ·71 | 5 | 18 |
| Girvan (Pinmore) | *Ayr* | 3·77 | 7·24 | 184 | 192 | ·81 | 14 | 28 |
| Glasgow (Queen's Park) | *Renfrew* | 2·61 | 5·41 | 137 | 207 | ·77 | 5 | 25 |
| Islay (Eallabus) | *Argyll* | 3·82 | 6·54 | 166 | 171 | ·61 | 27 | 30 |
| Mull (Quinish) | „ | 4·43 | 8·60 | 218 | 194 | ·92 | 8 | 30 |
| Loch Dhu | *Perth* | 6·59 | 13·70 | 348 | 208 | 1·50 | 8 | 27 |
| Dundee (Eastern Necropolis) | *Forfar* | 2·06 | 2·20 | 56 | 107 | ·75 | 5 | 16 |
| Braemar (Bank) | *Aberdeen* | 2·93 | 3·90 | 99 | 133 | ·90 | 16 | 23 |
| Aberdeen (Cranford) | „ | 2·58 | 2·28 | 58 | 88 | ·73 | 5 | 14 |
| Gordon Castle | *Moray* | 2·32 | 2·04 | 52 | 88 | ·51 | 29 | 18 |
| Fort William (Atholl Bank) | *Inverness* | 6·60 | 14·94 | 380 | 226 | 1·55 | 23 | 30 |
| Alness (Ardross Castle) | *Ross* | 3·26 | 3·79 | 96 | 116 | ·86 | 8 | 27 |
| Loch Torridon (Bendamph) | „ | 7·50 | 15·78 | 401 | 210 | 1·46 | 8 | 31 |
| Stornoway | „ | 4·10 | 6·69 | 170 | 163 | ·55 | 9 | 31 |
| Wick | *Caithness* | 2·27 | 1·61 | 41 | 71 | ·32 | 5 | 24 |
| Glanmire (Lota Lodge) | *Cork* | 3·10 | 3·19 | 81 | 103 | ·60 | 12 | 28 |
| Killarney (District Asylum) | *Kerry* | 4·71 | 5·84 | 148 | 124 | ·69 | 28 | 28 |
| Waterford (Brook Lodge) | *Waterford* | 2·75 | 3·31 | 84 | 120 | ·70 | 15 | 22 |
| Nenagh (Castle Lough) | *Tipperary* | 3·09 | 4·06 | 103 | 131 | ·52 | 17 | 27 |
| Ennistymon House | *Clare* | 3·40 | 6·14 | 156 | 181 | ·63 | 28 | 27 |
| Gorey (Courtown House) | *Wexford* | 2·31 | 3·19 | 81 | 138 | 1·17 | 25 | 19 |
| Abbey Leix (Blandsfort) | *Queen's Co.* | 2·62 | 3·21 | 82 | 123 | ·35 | 15 | 22 |
| Dublin (FitzWilliam Square) | *Dublin* | 1·94 | 1·99 | 50 | 103 | ·46 | 14 | 21 |
| Mullingar (Belvedere) | *Westmeath* | 2·70 | 2·73 | 69 | 101 | ·57 | 28 | 23 |
| Woodlawn | *Galway* | 3·14 | 3·69 | 94 | 118 | ·70 | 28 | 28 |
| Crossmolina (Enniscoe) | *Mayo* | 4·52 | 6·62 | 168 | 147 | ·86 | 3 | 30 |
| Collooney (Markree Obsy.) | *Sligo* | 3·39 | 4·12 | 105 | 121 | ·45 | 3 | 29 |
| Seaforde | *Down* | 2·92 | 3·43 | 87 | 117 | ·48 | 15 | 26 |
| Ballymena (Harryville) | *Antrim* | 3·15 | 3·70 | 94 | 117 | ·39 | 17 | 25 |
| Omagh (Edenfel) | *Tyrone* | 3·14 | 5·11 | 130 | 163 | ·51 | 3 | 31 |

## Supplementary Rainfall, March 1921.

| Div. | STATION. | RAIN. in. | RAIN. mm. | Div. | STATION. | RAIN. in. | RAIN. mm. |
|---|---|---|---|---|---|---|---|
| II | Ramsgate | ·94 | 24 | XII. | Langholm, Drove Rd. | 7·84 | 199 |
| ,, | Sevenoaks, Speldhurst | 1·67 | 42 | XIII. | Selkirk, Hangingshaw | 4·10 | 104 |
| ,, | Hailsham Vicarage | 1·71 | 43 | ,, | North Berwick Res. | 1·78 | 45 |
| ,, | Totland Bay, Aston | 1·06 | 27 | ,, | Edinburgh, Royal Ob. | 2·08 | 53 |
| ,, | Ashley, Old Manor Ho. | 1·33 | 34 | XIV. | Biggar | 4·46 | 113 |
| ,, | Grayshott | 1·53 | 39 | ,, | Leadhills | 12·85 | 326 |
| ,, | Ufton Nervet | 1·26 | 32 | ,, | Maybole, Knockdon | 6·21 | 158 |
| III. | Harrow Weald, Hill Ho. | 1·44 | 37 | XV. | Dougarie Lodge | 5·12 | 130 |
| ,, | Pitsford, Sedgebrook | ·86 | 22 | ,, | Inveraray Castle | 14·57 | 370 |
| ,, | Chatteris, The Priory | ·89 | 23 | ,, | Holy Loch, Ardnadam | 12·66 | 322 |
| IV. | Elsenham, Gaunts End | 1·26 | 32 | XVI. | Loch Venachar | 9·30 | 236 |
| ,, | Lexden, Hill House | ·74 | 19 | ,, | Glenquey Reservoir | 9·80 | 249 |
| ,, | Aylsham, Rippon Hall | 1·08 | 27 | ,, | Loch Rannoch, Dall | 7·14 | 181 |
| ,, | Swaffham | 1·15 | 29 | ,, | Trinafour | 10·26 | 261 |
| V. | Devizes, Highclere | 1·48 | 38 | ,, | Coupar Angus | 2·46 | 62 |
| ,, | Weymouth | 1·25 | 32 | ,, | Montrose Asylum | 2·29 | 58 |
| ,, | Ashburton, Druid Ho. | 4·17 | 106 | XVII. | LogieColdstone, Loanh'd | 1·67 | 42 |
| ,, | Cullompton | 2·18 | 55 | ,, | Fyvie Castle | 1·94 | 49 |
| ,, | Hartland Abbey | 3·46 | 88 | ,, | Grantown-on-Spey | 1·50 | 38 |
| ,, | St. Austell, Trevarna | 3·43 | 87 | XVIII. | Cluny Castle | 6·75 | 171 |
| ,, | North Cadbury Rec. | 2·09 | 53 | ,, | Loch Quoich, Loan | 28·50 | 724 |
| ,, | Cutcombe, Wheddon Cr. | 3·88 | 99 | ,, | Drumnadrochit | 4·96 | 126 |
| VI. | Clifton, Stoke Bishop | 1·96 | 50 | ,, | Arisaig, Faire-na-Sguir | .. | .. |
| ,, | Ledbury, Underdown | 1·09 | 28 | ,, | Skye, Dunvegan | 9·91 | 252 |
| ,, | Shifnal, HattonGrange | 1·57 | 40 | ,, | Glencarron Lodge | 11·92 | 303 |
| ,, | Ashbourne, Mayfield | 2·05 | 52 | ,, | Dunrobin Castle | 2·36 | 60 |
| ,, | Barnt Green, Upwood | 1·04 | 26 | XIX. | Tongue Manse | 3·50 | 89 |
| ,, | Blockley, Upton Wold | 1·73 | 44 | ,, | Melvich Schoolhouse | 1·88 | 48 |
| VII. | Grantham, Saltersford | ·76 | 19 | ,, | Loch More, Achfary | 12·10 | 307 |
| ,, | Louth, Westgate | 1·05 | 27 | XX. | Dunmanway Rectory | 6·10 | 155 |
| ,, | Mansfield, West Bank | 1·19 | 30 | ,, | Mitchelstown Castle | 2·84 | 72 |
| VIII. | Nantwich, Dorfold Hall | 1·50 | 38 | ,, | Gearahameen | 10·50 | 267 |
| ,, | Bolton, Queen's Park | 3·28 | 83 | ,, | Darrynane Abbey | 5·56 | 141 |
| ,, | Lancaster, Strathspey | 4·07 | 103 | ,, | Clonmel, Bruce Villa | 3·76 | 96 |
| IX. | Wath-upon-Dearne | ·73 | 18 | ,, | Cashel, Ballinamona | 2·73 | 69 |
| ,, | Bradford, Lister Park | 2·01 | 51 | ,, | Roscrea, Timoney Pk. | 2·45 | 62 |
| ,, | West Witton | 2·28 | 58 | ,, | Foynes | 3·62 | 92 |
| ,, | Scarborough, Scalby | 1·07 | 27 | ,, | Broadford, Hurdlesto'n | 3·64 | 92 |
| ,, | Middlesbro', Albert Pk. | ·86 | 22 | XXI. | Kilkenny Castle | 2·65 | 67 |
| ,, | Mickleton | 2·80 | 71 | ,, | Rathnew, Clonmannon | 2·54 | 64 |
| X. | Bellingham | 2·60 | 66 | ,, | Hacketstown Rectory | 2·85 | 72 |
| ,, | Ilderton, Lilburn | 1·66 | 42 | ,, | Balbriggan, Ardgillan | 2·34 | 59 |
| ,, | Orton | 9·31 | 236 | ,, | Drogheda | 2·36 | 60 |
| XI. | Llanfrechfa Grange | 3·09 | 78 | ,, | Athlone, Twyford | 3·33 | 85 |
| ,, | Treherbert, Tyn-y-waun | 13·34 | 339 | ,, | Castle Forbes Gdns. | 2·64 | 67 |
| ,, | Carmarthen, The Friary | 4·66 | 118 | XXII. | Ballynahinch Castle | 7·03 | 179 |
| ,, | Fishg'rd, Goodwick Stn. | 5·81 | 148 | ,, | Galway Grammar Sch. | 5·14 | 131 |
| ,, | Lampeter, Falcondale | 6·01 | 153 | ,, | Westport House | 6·27 | 159 |
| ,, | Crickhowell, Talymaes | 2·50 | 64 | XXIII. | Enniskillen, Portora | 3·50 | 89 |
| ,, | B'ham W.W., Tyrmyndd | 6·41 | 163 | ,, | Armagh Observatory | 2·61 | 66 |
| ,, | Lake Vyrnwy | 6·05 | 154 | ,, | Warrenpoint | 3·06 | 78 |
| ,, | Llangynhafal, P. Drâw | 1·65 | 42 | ,, | Belfast, Cave Hill Rd. | 3·37 | 86 |
| ,, | Oakley Quarries | 12·47 | 317 | ,, | Glenarm Castle | 3·76 | 96 |
| ,, | Dolgelly, Bryntirion | 7·92 | 201 | ,, | Londonderry, Creggan | 4·23 | 107 |
| ,, | Snowdon, L. Llydaw | | | ,, | Sion Mills | 4·92 | 125 |
| ,, | Lligwy | 3·86 | 98 | ,, | Milford, The Manse | 5·11 | 130 |
| XII. | Stoneykirk, ArdwellHo. | 3·77 | 96 | ,, | Narin, Kiltoorish | 6·69 | 170 |
| ,, | Carsphairn, Shiel | 13·70 | 348 | ,, | Killybegs, Rockmount | 6·83 | 174 |

## Climatological Table for th

| STATIONS | PRESSURE: Mean of Day M.S.L. | PRESSURE: Diff. from Normal | TEMPERATURE: Absolute: Max. | Date | Min. | Date | Mean Values: Max. | Min. | ½ max. and min. | Diff. from Norm |
|---|---|---|---|---|---|---|---|---|---|---|
| | mb. | mb. | ° F. | | ° F. | | ° F. | ° F. | ° F. | ° F. |
| London, Kew Observatory | 1015·3 | +1·6 | 71 | 5 | 32 | 28 | 59·4 | 44·6 | 52·0 | +2· |
| Gibraltar | 1015·8 | +0·6 | 78 | 4 | 51 | 28, 31 | 71·5 | 58·0 | 64·7 | −1· |
| Malta | 1012·6 | −3·1 | 87 | 4 | 57 | 27 | 76·3 | 66·9 | 71·6 | +1· |
| Sierra Leone | 1012·6 | +0·7 | 90 | 5, 20, 28 | 69 | sev. | 86·9 | 70·9 | 78·9 | −1· |
| Lagos, Nigeria | 1012·8 | +1·1 | 87 | 7 | 70 | 16 | 84·6 | 74·4 | 79·5 | +0· |
| Kaduna, Nigeria | 1013·4 | +3·1 | 91 | 7 | 63 | 12, 13, 19 | 87·6 | 66·2 | 76·9 | −0· |
| Zomba, Nyasaland | 1009·8 | −0·7 | 97 | 7 | 56 | 11 | 87·3 | 64·9 | 76·1 | +2· |
| Salisbury, Rhodesia | 1010·3 | −2·1 | 94 | 17 | 52 | 18 | 88·0 | 59·3 | 73·7 | +3· |
| Cape Town | 1018·6 | +1·2 | 81 | 31 | 43 | 4 | 68·4 | 52·2 | 60·3 | −0· |
| Johannesburg | 1014·3 | +0·2 | 89 | 20 | 32 | 7 | 72·8 | 51·2 | 62·0 | −0· |
| Mauritius | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Bloemfontein | .. | .. | 93 | 20 | 35 | 7 | 77·9 | 48·9 | 63·4 | −1· |
| Calcutta, Alipore Obsy. | 1009·2 | −0·2 | 93 | 1 | 71 | 31 | 87·8 | 75·6 | 81·7 | +1· |
| Bombay | 1007·5 | −2·2 | 94 | 26 | 74 | 31 | 90·0 | 78·5 | 84·3 | +2· |
| Madras | 1008·8 | −0·1 | 98 | 11 | 73 | 27 | 89·5 | 76·5 | 83·0 | +0· |
| Colombo, Ceylon | 1010·4 | +0·6 | 87 | 25 | 72 | 20 | 85·8 | 75·0 | 80·4 | −0· |
| Hong Kong | 1013·5 | −0·1 | 87 | 4 | 68 | 18 | 80·6 | 72·5 | 76·5 | −0· |
| Sydney | 1017·6 | +2·7 | 82 | 8 | 49 | 3 | 71·4 | 55·9 | 63·7 | +0· |
| Melbourne | 1016·7 | +2·1 | 86 | 31 | 38 | 2 | 68·0 | 49·9 | 58·9 | +1· |
| Adelaide | 1016·8 | +0·7 | 90 | 31 | 42 | 25 | 73·3 | 52·4 | 62·9 | +1· |
| Perth, Western Australia | 1017·3 | +0·5 | 87 | 19 | 46 | 2 | 71·8 | 53·5 | 62·7 | +1· |
| Coolgardie | 1015·3 | +0·1 | 96 | 29 | 41 | 1, 22 | 81·0 | 51·1 | 66·1 | +2· |
| Brisbane | 1017·4 | +1·2 | 92 | 27 | 53 | 1 | 78·2 | 60·5 | 69·3 | −0· |
| Hobart, Tasmania | 1013·6 | +3·0 | 77 | 10 | 38 | 1 | 65·4 | 47·4 | 56·4 | +2· |
| Wellington, N.Z. | 1012·6 | +0·3 | 64 | 22 | 49 | 26 | 59·2 | 48·5 | 53·9 | −0· |
| Suva, Fiji | 1012·5 | −0·7 | 82 | 25 | 65 | 7 | 79·6 | 69·1 | 74·3 | −1· |
| Kingston, Jamaica | 1011·8 | −0·1 | 94 | 21 | 68 | 5 | 90·8 | 73·8 | 82·3 | +1· |
| Grenada, W.I. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Toronto | 1017·9 | −0·1 | 81 | 21 | 33 | 29, 30 | 64·4 | 45·5 | 54·9 | +8 |
| Winnipeg | 1012·9 | −2·4 | 83 | 7 | 16 | 28 | 60·1 | 37·7 | 48·9 | +8 |
| St. John, N.B. | 1015·2 | −1·3 | 67 | 1 | 35 | 31 | 58·5 | 44·6 | 51·5 | +6 |
| Victoria, B.C. | 1014·5 | −3·1 | 59 | 9 | 37 | 31 | 52·8 | 44·3 | 48·5 | −1 |

LONDON, KEW OBSERVATORY.—Mean speed of wind 6·5 mi/hr ; 1 day with thunder he 12 days with fog.

GIBRALTAR.—1 day with thunder heard, 2 days with fog.

MALTA.—Prevailing wind direction NW. ; mean speed 6·3 mi/hr.

SIERRA LEONE.—Prevailing wind direction SW. ; 25 days with thunder heard.

SALISBURY, RHODESIA.—Prevailing wind direction NE. ; 1 day with thunder heard.

## British Empire, October 1920.

| TEMPERATURE | | | | PRECIPITATION | | | | BRIGHT SUNSHINE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Absolute | | Relative Humidity | Mean Cloud Am'nt | Amount | | Diff. from Normal | Days | Hours per day | Percentage of possible | STATIONS |
| Max. in Sun °F. | Min. on Grass °F. | % | 0–10 | in. | mm. | mm. | | | | |
| 122 | 22 | 82 | 5·5 | 1·68 | 43 | − 26 | 9 | 3·7 | 34 | London, Kew Observatory. |
| 130 | 46 | 75 | 3·9 | 2·70 | 69 | − 15 | 9 | .. | .. | Gibraltar. |
| 144 | .. | 76 | 6 | 4·15 | 105 | + 37 | 12 | 6·4 | 57 | Malta. |
| .. | .. | 75 | 5·5 | 7·69 | 195 | −129 | 20 | .. | .. | Sierra Leone. |
| 164 | 66 | 66 | 7·2 | 5·06 | 129 | − 67 | 14 | .. | .. | Lagos, Nigeria. |
| .. | .. | 83 | .. | 2·91 | 74 | + 14 | 9 | .. | .. | Kaduna, Nigeria. |
| .. | .. | 76 | 3·0 | 3·03 | 77 | + 39 | 6 | .. | .. | Zomba, Nyasaland. |
| 153 | 44 | 49 | 3·1 | 0·58 | 15 | − 16 | 5 | .. | .. | Salisbury, Rhodesia. |
| .. | .. | 68 | 4·6 | 2·12 | 54 | + 10 | 10 | .. | .. | Cape Town. |
| .. | 32 | 56 | 4·5 | 5·03 | 128 | + 67 | 12 | 8·2 | 65 | Johannesburg. |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | Mauritius. |
| .. | .. | 49 | 3·3 | 3·38 | 86 | + 43 | 7 | .. | .. | Bloemfontein. |
| .. | 65 | 67 | 4·9 | 5·73 | 146 | + 47 | 4 | .. | .. | Calcutta, Alipore Obsy. |
| 139 | 63 | 70 | 3·5 | 0·34 | 9 | − 38 | 2 | .. | .. | Bombay. |
| .. | .. | 84 | 6·8 | 21·47 | 545 | +259 | 16 | .. | .. | Madras. |
| 161 | 70 | 74 | 7·5 | 15·27 | 388 | + 31 | 22 | .. | .. | Colombo, Ceylon. |
| .. | .. | 70 | 4·7 | 6·19 | 157 | + 32 | 14 | 7·8 | 67 | Hong Kong. |
| 141 | 43 | 66 | 5·4 | 1·72 | 44 | − 31 | 12 | 6·5 | .. | Sydney. |
| 145 | 33 | 67 | 5·9 | 3·72 | 94 | + 28 | 14 | .. | .. | Melbourne. |
| 152 | 31 | 57 | 4·7 | 2·90 | 74 | + 30 | 9 | .. | .. | Adelaide. |
| .. | 31 | 60 | 4·9 | 1·45 | 37 | − 17 | 12 | .. | .. | Perth, Western Australia. |
| 149 | 38 | 36 | 2·5 | 0·31 | 8 | − 11 | 6 | .. | .. | Coolgardie. |
| 150 | 47 | 63 | 5·5 | 2·16 | 55 | − 14 | 11 | .. | .. | Brisbane. |
| 146 | 30 | 63 | 6·2 | 0·88 | 22 | − 35 | 15 | 8·0 | 61 | Hobart, Tasmania. |
| 136 | 21 | 78 | 6·9 | 3·41 | 87 | − 20 | 12 | 5·4 | 41 | Wellington, N.Z. |
| .. | .. | 83 | .. | 5·40 | 137 | − 61 | 22 | .. | .. | Suva, Fiji. |
| .. | .. | 74 | 5·9 | 1·23 | 31 | −159 | 7 | .. | .. | Kingston, Jamaica. |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | Grenada, W.I. |
| .. | .. | 88 | 4·3 | 3·83 | 97 | + 35 | 10 | .. | .. | Toronto. |
| .. | .. | 75 | 3·7 | 0·21 | 5 | − 33 | 3 | .. | .. | Winnipeg. |
| .. | .. | 81 | 4·8 | 3·21 | 82 | − 33 | 6 | .. | .. | St. John, N.B. |
| .. | .. | 89 | 6·7 | 4·03 | 102 | + 37 | 20 | .. | .. | Victoria, B.C. |

BLOEMFONTEIN.—Highest rainfall for October; lowest absolute min. temp. for October.

MADRAS.—17 days with thunder heard.

COLOMBO, CEYLON.—Prevailing wind direction WSW.; mean speed 4·8 mi/hr; 3 days with thunder heard.

HONG KONG.—Prevailing wind direction E.; mean speed 10·3 mi/hr.

brought rain to the south-east of England also affected the adjacent regions of the Continent. In France the only large rainfall readings recorded in the *Daily Weather Report* were 51 mm. at Lyons on the 7th and 25 mm. at Biarritz on the 20th. In the Mediterranean area the conditions were mainly anticyclonic, but shallow depressions caused occasional heavy falls of rain. On the 6th 59 mm. of rain fell at Gibraltar, 30 mm. at Sanguinaire (Corsica), and there were some heavy falls in Italy. Limasol (Cyprus) had 28 mm. on the 9th and 26 mm. on the 13th. There were readings of 40 mm. at Malta on the 10th, and also at Sanguinaire on the 21st.

Abnormally high temperatures have prevailed all the winter in Switzerland, even at the greater altitudes. Early in January the famous Rhine Falls at Schaffhausen had vanished* and the river-bed was largely dry. Although frequent snowfalls occurred in the higher regions in February, the winter has been singularly deficient in this respect. The six weeks ending March 13th were particularly sunny. The Rhine and Rhone dwindled to half their ordinary volume. The level of the lakes fell considerably and most of the steamer service had to be suspended. Electric service was very limited because of the lack of water power. There was practically no snow under 4,000 feet, and such a dry season has not been experienced for 90 years.

At the beginning of the month torrential rains fell in South Australia, causing such serious floods that the ports had to be closed and traffic on the Trans-continental railway suspended. At the same time good rain fell throughout practically the whole of New South Wales. A message received on the 17th stated that heavy rain had put out the fires in South Gippsland (Victoria).

In Canada on the 28th the St. Lawrence river experienced the earliest spring opening for the past 40 years, the normal time being about April 20th. A message despatched from Toronto on the 21st states that there have been two severe storms in Ontario: a cloud-burst at Port Hope on Lake Ontario and a wind storm in Bruce County (Lake Huron). There was not much loss of life, but considerable damage to property.

The Newfoundland sealing fleet which went out on the 10th was unable to find the herds owing to heavy ice.

A telegram dated March 18th stated that famine had been declared in parts of the Bellary and Anantapur districts of the Madras Presidency. Light to heavy rain fell in parts of Burma, Bengal, Bihar and Orissa, and North-west Frontier Province, but the weather continued dry in other provinces.

* Presumably because all the available water was required for the power-station.

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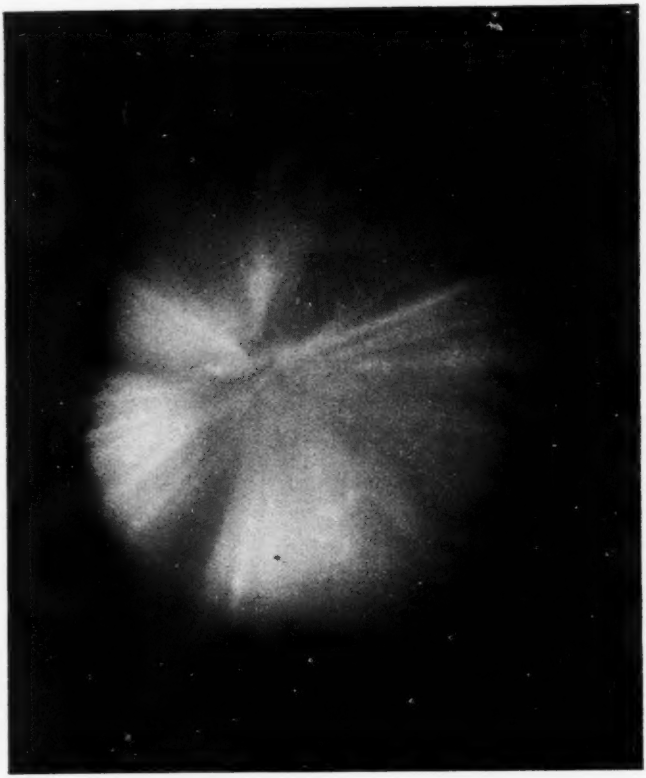

FIG. 1.—Corona of 23rd March, 1920, observed in Norway.